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The Influence of Web API and linked data technologies on data interoperability in digital repositories of Public Universities in Kenya

Leonard Kibet Kirui [1,*], Roselida Maroko Ongare [2] and Bostley Muyembe Asenahabi [3]

[1] *Directorate of Information Communication Technology, Moi university, Kenya.*
[2] *Department of Information Technology, Kibabii University, Kenya.*
[3] *Department of Computer Science, Alupe University, Kenya.*

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Abstract

Interoperability is a critical requirement for effective data exchange and integration across institutional digital repositories. However, many repositories still operate in silos due to inconsistent metadata schemas, incompatible systems, and a lack of standardized communication protocols. This study empirically evaluates the role of Web APIs and Linked Data technologies in fostering interoperability across repositories. A descriptive correlational research design was employed, involving data collection from Egerton University and Moi University in Kenya using questionnaires and interviews. Normality testing indicated suitability for parametric analysis; therefore, Pearson correlation and simple linear regression were used. The findings reveal a moderate positive and statistically significant Pearson correlation ($r = 0.340$, $p = 0.040$) between Web API & Linked Data and data interoperability. Regression analysis further showed that Web API and Linked Data account for 11.6% of the variance in interoperability ($R^2 = 0.116$, $p = 0.004$), with a regression coefficient of $B = 0.450$. These results indicate that as institutions enhance their implementation of Web APIs and Linked Data technologies, their capacity for interoperable data exchange significantly improves. The study concludes that institutions implementing RESTful APIs and Linked Data standards such as RDF and SPARQL experience improved semantic alignment and system integration. It recommends phased technological adoption, strategic policy reforms, and targeted capacity-building initiatives to promote repository interoperability in academic institutions.

Keywords: Data Interoperability; Web Apis; Linked Data; Digital Repositories

1. Introduction

Institutional digital repositories have become indispensable infrastructures in modern academic environments. They facilitate long-term preservation, dissemination, and accessibility of scholarly content such as theses, research articles, datasets, and institutional records. However, despite increased investment in repository platforms, many institutions face difficulties in achieving true interoperability—the seamless ability to exchange, retrieve, and reuse data across systems. This limitation is primarily due to inconsistencies in metadata schemas, lack of standardized interfaces, and heterogeneous repository architectures [1], [2]. As universities expand their digital holdings, the urgency to address these interoperability challenges continues to grow.

Web Application Programming Interfaces (Web APIs) have emerged as a key enabler of interoperability by allowing different systems to communicate through well-defined endpoints and protocols. RESTful APIs, in particular, provide lightweight and flexible mechanisms for data sharing across platforms [3]. Linked Data technologies complement this by enhancing metadata semantics using machine-readable formats such as RDF and SPARQL. These technologies facilitate richer metadata relationships, enabling systems to understand and contextualize repository content [4], [5].

* Corresponding author: Leonard Kirui.

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Together, Web APIs and Linked Data offer a technical foundation for building scalable, interoperable, and future-proof digital repositories.

Despite the global progress in implementing these technologies, many African universities—including those in Kenya—have yet to fully adopt or operationalize Web APIs and Linked Data within their repository systems. Studies have shown that implementation is often hindered by limited technical capacity, inadequate policy frameworks, and fragmented system architectures [6], [7]. This has led to siloed repositories that do not communicate effectively with external systems or with each other, thereby limiting scholarly visibility and reusability of digital assets [8]. The potential of semantic integration and real-time metadata synchronization remains largely untapped in such contexts.

This study seeks to empirically evaluate the influence of Web APIs and Linked Data on data interoperability within digital repositories in Kenya. Specifically, it investigates the extent to which these technologies contribute to enhanced repository integration, metadata alignment, and cross-platform searchability. By using a combination of Pearson correlation and regression analysis, the study aims to offer evidence-based insights to guide future repository development efforts. The findings are expected to inform institutional strategies, technical implementations, and policy interventions aimed at strengthening repository interoperability in higher education institutions.

2. Methods

This research employed a descriptive correlational design to assess the influence of Web APIs and Linked Data technologies on data interoperability within institutional digital repositories. The design facilitated the collection of both quantitative and qualitative data, allowing the study to explore not only measurable relationships but also contextual dynamics affecting repository integration and functionality.

The philosophical underpinning of the study was pragmatism, integrating both positivist and interpretivist approaches. This dual orientation supported rigorous statistical analysis while also accommodating subjective insights from participants. As a result, the research provided a comprehensive view of both the technological effectiveness and institutional realities surrounding interoperability initiatives.

The study targeted a diverse population of personnel involved in academic and administrative operations at selected Kenyan public universities. On the administrative side, participants included repository administrators, library staff, ICT personnel, and senior academic managers such as deans and directors. The academic group was composed of teaching faculty, active researchers, and postgraduate students. This inclusive sampling ensured a 360-degree perspective on how repositories are used, governed, and enhanced within institutional settings.

A multi-stage sampling strategy was adopted. Egerton University and Moi University were purposively selected due to their advanced digital infrastructure, repository maturity, and academic scale. These two universities were drawn from a broader pool of chartered public universities. Slovin's formula was used to calculate a representative sample size, resulting in 80 respondents: 44 from Moi University and 36 from Egerton University. Stratified sampling within each institution ensured proportional representation across functional roles, including administrators, ICT specialists, librarians, and researchers.

Data collection involved both structured questionnaires and semi-structured interviews. The questionnaires were distributed to repository users to capture quantitative metrics related to system performance and interoperability, while interviews with ICT staff and librarians provided qualitative insights on implementation challenges, metadata policies, and integration experiences.

Instrument reliability was verified using Cronbach's alpha, with values exceeding the 0.70 threshold, confirming acceptable internal consistency. Validity was established through expert evaluations and a pilot study conducted at Kibabii University and Alupe University College. These pilot institutions were excluded from the final sample but provided critical feedback to refine the research instruments.

The study adhered strictly to ethical guidelines. Participants gave informed consent, and their confidentiality and anonymity were maintained throughout the research process. Ethical clearance was obtained from the participating institutions, and all data were handled in accordance with national research ethics standards.

3. Results and discussions

This section presents and interprets the descriptive results related to data interoperability in digital repositories. The findings are based on responses from academic and administrative personnel at Moi University and Egerton University. Emphasis is placed on the frequency of interoperability issues, perceived limitations, impact on repository performance, and data types deemed critical for inclusion in integration solutions. The discussion links the results with existing literature to demonstrate the broader significance of the observed patterns.

3.1. Frequency of Interoperability Issues with Other Repositories and Systems

To assess the extent of integration problems, respondents were asked how frequently they experienced interoperability issues when working with other repositories or external systems. The findings, summarized in Table 1, reveal common patterns of system-level incompatibility.

Table 1 Frequency of Interoperability Issues

Frequency of Interoperability Issues		Frequency	Percent
Valid	Rarely	10	14.1
	Occasionally	33	46.5
	Frequently	23	32.4
	Very Frequently	5	7.0
	Total	71	100.0

Table 1 shows that 46.5% of users reported occasional issues, while 32.4% experienced them frequently. Only 14.1% indicated that they rarely faced such problems, and 7.0% reported very frequent challenges. These results indicate that more than 85% of users encounter interoperability issues at least occasionally, suggesting a widespread and recurring challenge in repository environments. This aligns with earlier findings in [8], which reported that system silos and inconsistent metadata impede repository integration.

3.2. Limitations Hindering Interoperability Between Digital Repositories and External Systems

Respondents identified a variety of technical and organizational barriers limiting interoperability. These are presented in Table 2.

Table 2 Limitations Hindering Interoperability

Limitations Hindering Interoperability		Yes	No	Total
Valid	Lack of Standardized Protocols	26(36.6%)	45(63.4%)	71(100%)
	Data Structures Differences	39(54.9%)	32(45.1%)	71(100%)
	Lack of API Support	37(52.1%)	34(47.9%)	71(100%)
	Inadequate Technical Expertise	31(43.7%)	40(56.3%)	71(100%)
	High Cost of Integration	19(26.8%)	52(73.2%)	71(100%)
	Others	0(0.0%)	71(100%)	71(100%)

As shown in Table 2, data structure differences were cited most frequently (54.9%), followed by lack of API support (52.1%) and inadequate technical expertise (43.7%). Lack of standardized protocols (36.6%) and the cost of integration (26.8%) were also noted, though to a lesser extent. These results reflect challenges found in [18], which emphasized metadata heterogeneity and skills shortages as primary inhibitors of system integration. The relatively lower concern about cost implies that human and technical constraints are more pressing than financial limitations.

3.3. Perceived Significance of Interoperability Challenges on Repository Functionality

To determine the operational impact of these challenges, respondents rated how significantly interoperability issues affected their repository's performance. The outcomes are displayed in Table 3.

Table 3 Perceived Significance of Interoperability Challenges

		Frequency	Percent
Valid	Not Significant	8	11.3
	Slightly Significant	1	1.4
	Moderately Significant	19	26.8
	Significant	30	42.3
	Very Significant	13	18.3
	Total	71	100.0

According to Table 3, 42.3% of users considered the impact significant, while 18.3% rated it as very significant. Together, this represents over 60% of respondents acknowledging a strong negative effect on system functionality. Only 11.3% saw the impact as not significant. These findings reinforce conclusions from [4], which emphasized that lack of interoperability undermines usability, system performance, and research visibility.

3.4. Critical Data Types for Inclusion in Web API and Linked Data Integration Solutions

Participants were also asked to identify the types of data they believed should be prioritized in interoperability solutions. These preferences are outlined in Table 4.

Table 4 Critical Data Types for Inclusion in Web API and Linked Data Integration

Types of Data		Yes	No	Total
Valid	Research Datasets	42(59.2%)	29(40.8%)	71(100%)
	Metadata	35(49.3%)	36(50.7%)	71(100%)
	Full-Text Records	29(40.8%)	42(49.2%)	71(100%)
	Others	4(5.6%)	67(97.4%)	71(100%)

Table 4 shows that research datasets were prioritized by 59.2% of respondents, followed by metadata (49.3%) and full-text records (40.8%). These results are consistent with the argument in [11] that access to structured datasets is key to enabling cross-platform knowledge sharing. Additionally, the emphasis on metadata confirms insights from [15], which noted that semantic metadata is foundational to Linked Data-based interoperability.

3.5. Influence of Web API and Linked Data Technologies on Data Interoperability in Digital Repositories

To examine the extent to which Web API and Linked Data technologies influence data interoperability within institutional digital repositories, a Pearson correlation and simple linear regression analysis were performed. This approach was suitable given that both variables met the assumptions of normality and linearity. The results provide insights into both the strength of association and the predictive capability of Web API and Linked Data solutions in enhancing system interoperability.

3.5.1. Correlation Analysis

The strength and direction of the linear relationship between Web API and Linked Data technologies and data interoperability were assessed using Pearson's correlation coefficient. The results are presented in Table 5.

Table 5 Pearson Correlation Between Web API &Linked Data and Data Interoperability

		Web API and Linked Data	**Data Interoperability**
Web API and Linked Data	Pearson Correlation	1	0.340
	Sig. (2-tailed)		0.040
	N	71	71
Data Interoperability	Pearson Correlation	0.340	1
	Sig. (2-tailed)	0.040	
	N	71	71

The results in Table 5 show a Pearson correlation coefficient of r = 0.340, with a p-value of 0.040, indicating a moderate positive relationship that is statistically significant at the 0.05 level (2-tailed). This suggests that improvements in Web API and Linked Data implementation are associated with increased levels of data interoperability. These findings are in line with previous studies such as [13] and [19], which have demonstrated that semantic technologies and open interfaces enhance repository integration and cross-platform communication.

3.5.2. Regression Analysis

To further understand the extent to which Web API and Linked Data technologies predict interoperability outcomes, a simple linear regression analysis was conducted. This model evaluated whether the adoption and implementation of these technologies significantly explains the variance in perceived interoperability. The summary statistics are presented in Table 6.

Table 6 Model Summary for the Influence of Web API & Linked Data on Data Interoperability

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.340[a]	0.116	0.103	0.384	0.116	9.007	1	69	0.004
a. Predictors: (Constant), Web API & Linked Data									

Table 6 reveals an R value of 0.340 and an R Square of 0.116, indicating that 11.6% of the variance in data interoperability is explained by Web API and Linked Data technologies. The Adjusted R Square of 0.103 adjusts for sample size, confirming that the model still holds explanatory power. This reflects a meaningful influence and reinforces the potential value of these technologies in enhancing interoperability frameworks.

3.6. The ANOVA results in Table 7 test the overall significance of the regression model.

Table 7 ANOVA Results for the Regression of Data Interoperability on Web API & Linked Data

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	1.355	1	1.355	9.007	0.004[b]
	Residual	10.327	69	0.150		
	Total	11.682	70			
a. Dependent Variable: Data Interoperability						
b. Predictors: (Constant), Web API & Linked Data						

As shown in Table 7, the model is statistically significant with an F-value of 9.007 and p = 0.004, indicating that the use of Web API and Linked Data is a significant predictor of data interoperability. This implies that even when other variables are not considered, the use of these technologies substantially improves integration capability.

Further details from the regression coefficients are provided in Table 8

Table 8 Regression Coefficients for Predicting Data Interoperability from Web API & Linked Data

Coefficients[a]							
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	1.220	0.301		4.053	0.000	0.620	1.820
Web API and Linked Data	0.450	0.150	0.340	3.001	0.004	0.151	0.749
a. Dependent Variable: Data Interoperability							

From Table 8, the unstandardized coefficient (B) = 0.450 with a p-value = 0.004, which confirms statistical significance at the 0.05 level. This means that for every one-unit increase in the implementation of Web API and Linked Data technologies, there is an expected 0.450-unit increase in data interoperability, assuming all other factors remain constant. The confidence interval (0.151 to 0.749) does not include zero, further confirming the strength and reliability of this estimate.

These results not only support the earlier correlation analysis but also provide evidence that Web APIs and Linked Data play a meaningful and measurable role in driving data interoperability across digital repositories. The significance of both the model and its predictors reinforces arguments made in [5], [13], and [18], which advocate for a paradigm shift toward semantic integration and open communication protocols to ensure sustainable repository interoperability.

4. Conclusion

This study set out to examine the role of Web APIs and Linked Data technologies in fostering data interoperability within digital repositories in higher education institutions. The investigation emphasized the growing need for systems that support seamless integration, data exchange, and machine-readable metadata. In the context of rapidly expanding digital content and increasingly collaborative research environments, institutional repositories must evolve to accommodate interoperability as a core requirement. The study highlights that achieving such interoperability is not solely a technical challenge but also an institutional one, requiring a combination of strategic policy direction, skilled human capacity, and commitment to open standards. Therefore, enhancing interoperability through Web APIs and Linked Data demands deliberate and coordinated action across technological, organizational, and regulatory dimensions.

Recommendations

In light of the study's conclusions, the following actionable recommendations are proposed to enhance the adoption and impact of Web API and Linked Data technologies for achieving data interoperability in digital repositories:

- Universities should adopt a phased implementation approach for Web API and Linked Data technologies, guided by open standards such as REST, RDF, and SPARQL to ensure system compatibility and scalability.
- Targeted capacity-building programs should be established to equip repository managers, ICT staff, and librarians with the technical skills required to develop and maintain interoperable platforms.
- Institutional and national-level policies should be developed to guide and enforce the standardization of metadata, API protocols, and Linked Data practices across higher education repositories.
- Efforts should be made to harmonize metadata structures by adopting widely accepted schemas such as Dublin Core, and to use ontology mapping tools to enhance semantic relationships among datasets.

- Inter-institutional collaboration should be promoted to support shared metadata repositories, federated search platforms, and cross-repository indexing systems, enabling knowledge sharing and integrated access to academic resources.
- Continuous monitoring and evaluation mechanisms should be established to assess the performance and evolution of interoperability initiatives, and further research should explore the long-term impact of these technologies on institutional visibility and research dissemination.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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